Modified for the Web

Lawrence Livermore National Laboratory

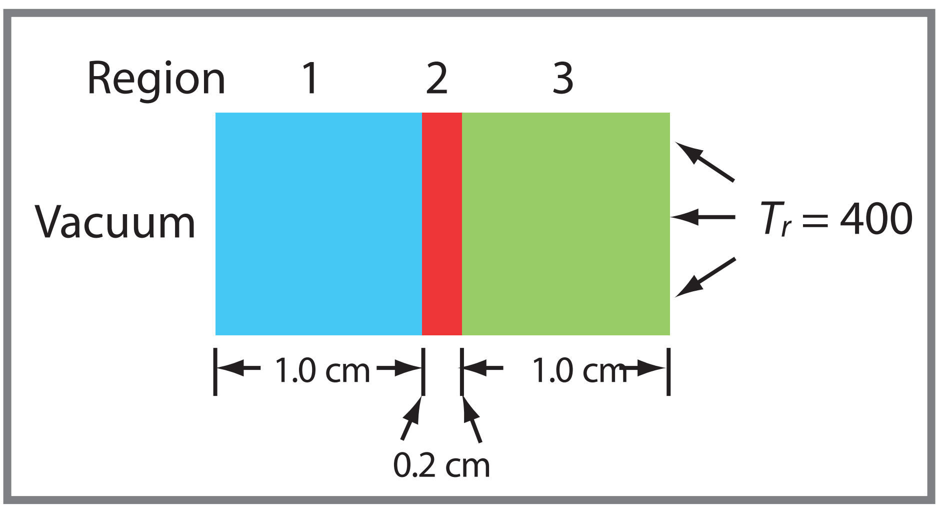
Development and Study of a Method Adaptive in Energy Variables for Solving the Radiation Transport Equation

Principal Investigators: Howard A. Scott (LLNL) and Alexander V. Gichuk (VNIIEF)

Project Description

The objective of this project is to develop and demonstrate more efficient methods for solving radiation transport equations using adaptivity in energy. Because the computational cost of a transport solution is roughly proportional to the number of energy groups used, minimizing the number of groups is desirable. However, energy discretizations of the transport equation necessarily approximate both material properties (opacities) and radiation spectra, so that the solution depends on the energy discretization. In addition, the solution may be sensitive to different spectral ranges in different regions of the domain. Adaptive techniques have the potential to address this issue, as well as to increase the accuracy and/or decrease the cost of a solution. This study addressed the need for increased efficiency by developing a numerical method using energy adaptivity.

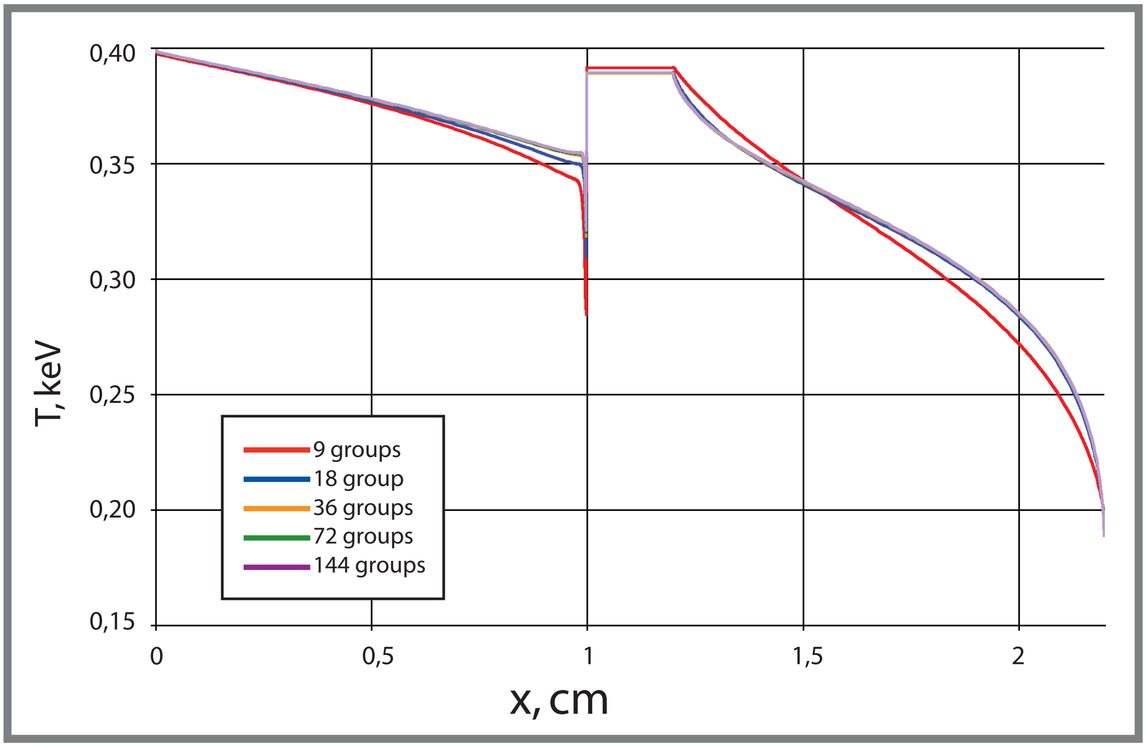
The algorithm for solving the radiation transport equation using an energy-adaptive method with dynamic criteria for constructing the energy grid was evaluated using a set of test problems. In addition to these problems, a test problem consisting of a planar one-dimensional system comprised of three regions, each with a uniform density and an initial temperature of 1 eV, was also used to test the algorithm. The transport coefficients were specified, and an isotropic radiation flux equivalent (400 eV blackbody) was incident on the boundary of region 3, with the boundary of region 1 being a free boundary. The diagnostic quantities of interest were the steady-state temperature profile and the temperature histories at positions throughout the three regions.



Schematic of test problem for energy adaptive studies.

Technical Purpose and Benefits

The simulation of multidimensional transport processes is an area of great interest. Deterministic methods, combined with improved discretization and acceleration techniques, hold the promise of accurate simulation of a variety of transport processes in complex geometries. However, the realization of this promise has proven to be very difficult, and further advances in algorithms are needed. One of the primary difficulties is that the number of variables required to model a given system can be extremely large, as the transport requires a description in six-dimensional phase space. Reduced dimensionality using spatial symmetries, diffusive transport, or energy-averaged variables is usually invoked to minimize the computational requirements, but each of these approximations has limited applicability. It remains true that resolved transport simulations of many physical systems remain beyond the reach of our most powerful computers. More efficient algorithms, such as the one demonstrated in this project, are needed.



Steady-state material temperature distribution for different numbers of groups.

ВНИИ
VNIIEF

Collaboration between Lawrence Livermore National Laboratory (LLNL), Livermore, CA, USA, and the Russian Federal Nuclear Center - All Russian Research Institute of Experimental Physics (RFNC-VNIIEF), Sarov, Russia

Lawrence Livermore National Laboratory

A Publication of the Office of Advanced Simulation & Computing, NNSA Defense Programs. SAND 2007-4400P
Issued by Sandia National Laboratories for NNSA's Office of Advanced Simulation & Computing, NA-114. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.